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AVIATION AND AIRCRAFT JOURNAL

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Bids Invited on Amphibious Passenger Planes

OUR readers' attention is drawn to a note appearing in this issue, regarding bids asked for amphibious passenger airplanes. The first of these machines, we understand, is to be used mainly for the personal pleasure of the prospective owner of the plane, although use in commercial operation may also follow.

It is interesting to note that the design has been prepared by a firm of consulting engineers to whom bids are to be sent, and who are acting on behalf of the prospective owner. This is closely analogous to the methods often followed in the case of yachts and motor boats, but the main point of interest of the invitation to bid seems to us the fact that aviation is apparently approaching the conditions found in the shipbuilding industry. We believe that this is quite encouraging to the aircraft industry.

Warping of Monoplane Wings

A RECENT report of the National Advisory Committee for Aeronautics investigates the importance of distortion effects in the wings of an airplane under differing deflections of front and rear spars. For a biplane with stagger or incidence wires this is shown to be unimportant. For a monoplane braced with rigid struts, but with a large overhang the effect may be very important, and may explain some otherwise mysterious failures with monoplanes of apparently enormous strength. For internally braced monoplanes, warping or distortional effects will have to be watched even more carefully. Some form of construction will have to be adopted whereby these effects can be adequately counteracted.

Effect of Engine on Control

A RECENT paper by Squadron-Leader R. M. Hill, a well-known and experienced pilot emphasizes the necessity of considering the stability and control of the airplane in direct relation to the engine, or more correctly of the propeller thrust and slip stream the propeller being actuated by the engine.

Designers have very often been satisfied that they have secured adequate stability and control on purely aerodynamic grounds, basing their conclusions on aerodynamic calculations or on tests in the wind-tunnel.

Results in the air have been disappointing at times in spite of careful and sound work when the effect of the engine on aerodynamic control has been neglected.

There are two most important relationships between the engine and the control and stability system. First the position of the thrust axis relative to the center of gravity of the airplane, second the presence or absence of the slipstream and its effect on the tail. The first is generally of small importance. The question of engine torque needs hardly be considered as a rule, but the effects of slip-stream can never be neglected.

Acting on the fin, which practical design considerations almost always prevent being disposed symmetrically in the slip-stream, the rotary motion of the slip-stream may produce a serious turning tendency on the plane as a whole by its unsymmetric action on the fin. This turning tendency is sometimes assumed to be due to the torque reaction of the engine, and capable of being removed by a wash-in or wash-out on the tips of the wings. This certainly will take care of the torque reaction but it can hardly counteract the turning tendency of the fin. If this is really violent as is the case in some planes, it seems advisable to change the vertical disposition of the fin area, by putting some of the fin area below the body for instance, or making the fin narrower and higher, or by juggling with the shape of the rudder. To use shock-absorbers on the rudder bar seems scarcely satisfactory. Sometimes an increase in propeller diameter will help since this may decrease the velocity of the slip-stream or spreading the slip-stream over a larger area cause the effect on the fin to be less.

Again the slip-stream acting on the horizontal tail-area may make a machine tail heavy when the engine is on by increasing the negative tail load on the tail. The remedy here would seem to be to give the tail less negative setting than wind-tunnel tests for calculations would indicate. The adjustable stabilizer is of course a powerful corrective, provided its range of action is large enough, but this is not as elegant a method as the perfect trim of a machine obtained by due allowance for slip-stream.

With the familiarity bred of long practice, and with the confidence which successful flying by skillful pilots ensures for machines not quite up to the standard of control obtainable, designers are apt to neglect these considerations, however much importance they may have once attached to them. When a practical aviator draws special attention to them, it may be safely concluded that it is not possible to neglect these points in the best interests of the art.

The Lemweber Helicopter

IN a previous issue of AVIATION a photograph was shown of the Lemweber Helicopter.

Chicago newspapers announce that secret but successful tests have been made at the Speedway Park, with a machine equipped with two Gnome motors of 100 horsepower each turning two ten-foot three bladed propellers of special design.

It is understood that in order to obtain varying conditions of flight, the propellers are fitted by means of an ingenious system of valves and compressed air.

The machine tested is only built for experimental purposes, and many refinements are to be introduced later.

An American Engine for Altitude Work

By Colonel Jesse G. Vincent

Vice President of Engineering, Packard Motor Car Co

One of the first American airplane engines especially designed for work in high altitudes has recently been completed for the United States Army Air Service and is known as the Packard "1237". Preliminary tests of this engine have been extremely satisfactory and indicate that its performance will considerably exceed the specifications laid down when the design was undertaken and will be particularly pleasing at the higher altitudes

Although it is a well-known fact that airplane engines are used fully 90 per cent of the time at altitudes above 5,000 ft, it has, nevertheless, been the practice in the past to judge such engines almost entirely on the basis of their ground performance. This has resulted in a tendency to design these engines for most efficient work at the low altitudes at which they are used only in the first ten or fifteen minutes of a flight In this engine for the first time in this country, an effort has been made to provide features that might not be wholly satisfactory on the ground but that would become unusually so at points above 5,000 ft.

It was more than natural that engines should be judged by their ground performance, considering the difficulties of estimating on the ground the conditions of a higher atmosphere. However, as our experience with airplane engines in flight increased, we have been forced to the conclusion that engines should practically be designed for altitude work and not for ground performance

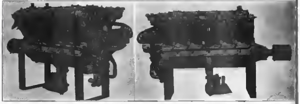
The decrease of barometric pressure at high altitudes is, of course, responsible for the necessity of a special engine output even at considerable heights due to the improved thermal efficiency.

In the second place, since the engine is designed for normal work at high altitudes, it is possible to make the cylinders larger in proportion to the rest of the working parts, as the stresses on these parts are far less than would be the case at sea level with cylinders of the same size. So this altitude engine is designed with cylinders large enough to bring the stresses on the working parts more nearly up to those on the normal sea level engine In other words, the engine is built "oversize".

The Packard "1237" is based upon the design for the Packard type "1116" which was one of the most successful post-war aircraft engines designed This engine incorporated many valuable features learned from war experience and in addition to being extremely economical and reliable, was one of the smoothest airplane engines ever built, running with exceptional freedom from vibration up to speeds in excess of 2,400 r.p.m

After the mechanical features of this engine were thoroughly proved, it was decided to put the finishing touch to the design by increasing the compression and making the cylinders ½ in larger in diameter with a view to obtaining efficiency of operation at altitudes never before obtained with such an engine. This was accordingly done, raising the cylinder displacement to 1237 cu in

It had originally been decided not to attempt to test this engine on full throttle at sea level since the increased stresses



Two Views of the Packard 1237 Engine

design for good performance in the rarer air We all know that the human body is best fitted for work nearer sea level and that at high altitudes respiration is difficult, for even the slightest manual labor necessitates great exertion. The same thing is true in the case of the airplane engine. If its respiratory organs are designed to deal with sea level conditions, it will not breathe easily at high altitudes, nor will it be capable of turning out as much work as it would if designed primarily for high altitude work.

To increase the efficiency of the airplane engine at high altitudes, the first necessity was to increase the compression ratio The real reason for the loss of power with the increase in altitude is that the air becomes thinner and the weight of fuel which can be consumed with a certain volume of air is correspondingly reduced with a resultant loss in power output By higher compression it becomes possible to maintain the might be more than the engine could be expected to stand. It had been the intention, of course, to supply the engine with a safety stop on the throttle until an altitude of at least 5,000 ft. should be reached, then the throttle could be opened wide

However, the engine behaved so well in its trial run on the dynamometer that it was decided to attempt a wide open throttle run The results were extremely gratifying and the engine showed itself capable of being run under these conditions at speeds in excess of 2400 r.p.m. A maximum of 400 hp. was developed although the engine was originally designed for only 300 hp This run was made on ordinary aviation gasoline and the engine did not suffer from either pre-ignition or detonation This is in marked contrast to somewhat similar oversize engines constructed in Germany which cannot be run wide open near the ground except with doped fuels.

While it is not intended that the "1237" engine is to be run

wide open near the ground for any long period, it is extremely gratifying to know that this excess of power is available for taking off with a heavily loaded machine and it is expected that this engine will prove very popular for commercial as well as for Army and Navy machines.

The changes in the engine design, it will be observed, give almost as much power for this engine as for the famous Liberty engine, which was over 100 lb heavier The advantages of this are obvious. It is possible to run this engine for comparatively heavy duty at low altitudes and to take off with a machine with very heavy loads. It is possible also to mount such an engine in an extremely light speed plane and

Propeller End View of the Packard "1237"

to develop from it very high rates of speed. On the other hand, an engine with these features will have peculiarly interesting advantages at the higher altitudes. Its light weight combined with the great proportionate power it can develop, will make it possible with such a power plant to produce speeds at altitudes which it is hoped will be beyond previous achievements with similar installations and at the same time to accomplish any given ceiling far more comfortably than with earlier makes of engines.

In commercial use, it is believed that an engine of this type will be particularly valuable in services such as that of the Post Office Department where it is frequently necessary to attain considerable heights in order to rise above storms at lower altitudes and to maintain that height with fairly heavy loads

And "1237" follows the general lines of the Packard aircraft engines as developed since the war and as a result of lessons learned during the struggle. It is of the twin-six type with the cylinder bank set at an included angle of 60 deg with overhead valves, of course, and with an arrangement of accessories which has been worked out to give the greatest possible accessibility. The bore is 5 in. and the stroke 5¼ in., and the actual displacement is 1237.005 cu. in.

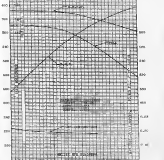
The crankshaft is of the now generally accepted type where a main bearing is provided on each side of each connecting rod and all bearings are carefully proportioned to give uniform life. The crank cheeks are of oval section which gives the best combination of rigidity with minimum weight. The diameter of the main bearings is 2⅝ in. and the length of the bearings is as follows:

No. 1—1⅝ in.
Nos. 2, 3, 5 and 6—1⅝ in.
No. 4—3 in.
No. 7—4.438 in.

The connecting rods are of the straddle type, suitably proportioned. The pistons are of aluminum alloy, die cast and equipped with floating piston rings. Three compression rings are fitted above the piston pin and one scraper ring below it. This scraper ring and its groove have proven in actual service to be extremely efficient in preventing excessive oil pumping The standard compression ratio is 6½ to 1, but pistons giving a compression ratio of 5½ to 1 can be furnished for low altitude work. The propeller hub is of the detachable type and is carefully designed to prevent the propeller from either freezing on the shaft or becoming loose.

The crank case is of the box-section design, parted on the center line of the crankshaft with the main bearings carried between. Great rigidity is obtained by means of long through bolts which unite the two halves into a single rigid unit.

The cylinders are of the individual steel type, which is now generally recognized as being the lightest and most efficient



Power Curve and Gas Consumption

type of design developed up to date. This type of cylinders gives the best possible water circulation and, therefore, the best valve cooling with the result that valve trouble is practically eliminated.

The valves are 2 in. in diameter in the clear with 30 deg seats, the intake valve lift being 7/16 in. and the exhaust ⅝ in. The cam shaft and rocker arm assemblies are of the enclosed type developed by Packard and used so successfully in the Liberty engine. So far as we know, this is the most successful type of valve operating mechanism that has ever been developed for steel cylinder aircraft engines. A tachometer drive is provided on the end of each cam shaft, per-

mitting the installation of a tachometer in each of the two cock pits, if desired.

The lubricating system is full pressure feed, operating with a dry pump and it contains many improvements dictated by long experience. The oil pump and oil screens are readily accessible for examination and adjustment. A tapped boss is provided in the crank case to serve for the oil tank vent. The engine is designed especially for the use of a nose radiator but is equally adaptable to any other type of radiator. The water pump is located under the rear end of the engine and the water outlet connections can be carried to four different directions, depending on the installation requirements, without any change in the standard engine. A tapped boss is provided for the insertion of a standard distant type thermometer to register the outlet water temperature.

The engine is equipped with a single duplex Packard Zenith carburetor of the single Venturi type mounted underneath the engine. In addition to making it very accessible, this provides for gravity feed. It also insures the greatest possible protection from fire, all vents being carried outside of the cowling so as to eliminate any possibility of fire from back fire. The use of a single float chamber for a multiple cylinder engine has been found to give the best results from the standpoint of uniform distribution and maximum economy. The single carburetor was something of an experiment but the difficulty of synchronizing two or four carburetors for throttle as well as altitude control was so great that it was decided to make the attempt, since it, of course, obviates these difficulties. Data which tests have given us in regard to power output, gasoline economy and inlet manifold depression, show a very satisfactory result and I think it extremely doubtful whether two or four carburetors could have given as good results.

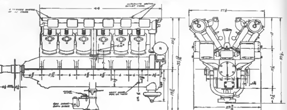
The location of the carburetor, in addition to its greater accessibility and safety from fire hazard, is also a great advance from the point of view of installation and maintenance. The gravity feed simplifies the whole system and the change is one which certainly should commend itself at once to the airplane engine designers.

An improved design of mixture control valve of the McCook Field type is used which gives uniform action and consistent results.

Standard ignition equipment consists of two 12 cylinder Dixie magnetos with fixed spark advance. A Vernier type magneto coupling permits the magnetos being properly set and synchronized in a minimum length of time. The magnetos are interchangeable, that is, they revolve in the same direction. Complete double ignition to two sets of spark plugs is provided and the engine will function properly on either set.

The standard engine has provisions for taking the following accessory equipment without any changes: rear end electric starter, gasoline pump, gun synchronizer drive and generator drive.

The utmost pains have been taken in all ways to insure accessibility of the working parts and to permit ease of installation. As a result the engine is believed to be in these respects the most successful of any of its type yet built.



Outline Drawings of the Packard 1237 Engine

The total weight of the engine, dry, is 735 lb. and on the maximum development of 398 hp. output this gives a weight of 1.85 lb. per hp. The gasoline consumption with wide open throttle averages almost exactly ½ lb. of fuel per horsepower hour. The accompanying graph gives further details in regard to the performances of the engine on the dynamometer.

Statical Longitudinal Stability of Airplanes

This report (N.A.C.A. No. 96), which is a continuation of the "Preliminary Report on Free Flight Testing" (No. 70), presents a detailed theoretical analysis of statical stability with free and locked controls and also the results of many free flight tests on several types of machines.

In developing the theory of stability with locked controls an expression for pitching moment is derived in simple terms by considering the total moment as the sum of the moments due to wings and tail surface. This expression, when differentiated with respect to angle of incidence, enables an analysis to be made of the factors contributing to the pitching moment. The effects of slip-stream and down-wash are also considered and it is concluded that the C. G. location has but slight effect on stability, and that stability is much improved by increasing the efficiency of the tail surfaces, which may be done by using an "inverted" tail plane.

The results of free flight tests with locked controls are discussed at length and it is shown that the agreement between the experimental results and theory is very satisfactory.

The theory of stability with free controls is not amenable to the simple mathematical treatment used in the case of locked controls, but a clear statement of the conditions enables several conclusions to be drawn, one of which is that the fixed tail surfaces should be much larger than the movable surfaces.

The discussion of flight tests with free controls covers the effect of C. G. position, tail setting and slip stream on the JN-4H and gives an analysis of the curves of forces on control stick for the VE 7, U.S.A. C-11, and Martin transport.

A copy of Report No. 96 may be obtained upon request from the National Advisory Committee for Aeronautics, Washington, D. C.

Two Years' Work at McCook Field

The functions of the Engineering Division, Air Service, can be outlined as follows:

To design, develop, and test all airplanes, airplane engines, accessories, and materials to meet the requirements of the Air Service; to prepare production drawings, specifications, and, where necessary, models of all aeronautical equipment for production; and to assist and supervise the experimental and production manufacture of all aeronautical equipment being designed and constructed for the Air Service by the aeronautical industry.

Work accomplished from July, 1919, to July, 1920

Airplanes

TYPE I. SINGLE-SEATER, PURSUIT

1. *Engineering Division, Model VCP-1.*—Construction and tests completed and developments and improvements progressing.

2. *Thomas-Morse, Model MB-3.*—Four experimental airplanes delivered by Thomas-Morse Aircraft Corp., under contract. Tests and necessary improvements and developments completed and incorporated in the contract for fifty airplanes being built by the Thomas-Morse Aircraft Corp., under contract dated June 19, 1920.

3. *Ordnance Engineering, Model Orenco D.*—Four experimental airplanes, delivered by the Ordnance Engineering Corp., under contract. Tests and necessary improvements and developments completed and incorporated in contract for fifty airplanes, being built by the Curtiss Airplane Corp., under contract dated June 15, 1920.

4. *Vought, Model VE-8.*—Two experimental airplanes, delivered by the Lewis & Vought Corp. under contract. Tests and development nearly completed.

5. *Ordnance Model D-2.*—Contract for three experimental airplanes let with the Ordnance Engineering Corp., April 23, 1920. Supervision and inspection of design and construction being maintained.

6. *Loening Monoplane, Scout.*—Contract for three experimental airplanes let with the Loening Aeronautical Engineering Corp., April 10, 1920. Supervision and inspection of design and construction being maintained.

All of the above airplanes are powered with Wright 300 hp. model H engines.

TYPE II. NIGHT PURSUIT, SINGLE-SEATER

1. *Curtiss Model.*—Contract for three experimental airplanes let with the Curtiss Airplane and Motors Corp., Feb. 23, 1920. Liberty, 220 hp., 6-cylinder engine used. Supervision and inspection of design and construction being maintained. The preliminary layout and design of this type was prepared by the Engineering Division.

TYPE III. COMBAT PURSUIT SINGLE-SEATER. (AIR-COOLED ENGINE)

Several preliminary layouts of design prepared by Engineering Division. Experimental construction temporarily suspended until suitable engine is developed.

TYPE IV. ARMORED PURSUIT SINGLE-SEATER

1. *Engineering division model GPX.*—Preliminary layout and design prepared by Engineering Division. Experimental construction temporarily suspended until Wright 300 hp. Cannon engine is developed.

TYPE V. TWO-SEATER PURSUIT

1. *Engineering division model XB-1A.*—Design constructed and tested by Engineering Division and made ready for production. The Wright 300 hp. Model H engine used in this airplane.

TYPE VI. ARMORED GROUND ATTACK THREE-SEATER

1. *Engineering division model GAX.*—Designed, constructed and tested by Engineering Division. A contract for the production of ten such airplanes was let with the Boeing Airplane Co., June 15, 1920. Two Liberty 400 hp. 12-cylinder engines used in this type.

TYPE VII. ARMORED INFANTRY LIAISON TWO-SEATER

1. *Ordnance model E.*—Contract for the construction of two experimental airplanes let with Ordnance Engineering Corp., January 26, 1920. Supervision and inspection of design and construction maintained. One Liberty 400 hp. 12-cylinder engine used in this type.

2. *Lepere model GH-11.*—This model with Liberty 400 hp. 12-cylinder engine being tested and developed.

TYPE VIII. NIGHT OBSERVATION TWO-SEATER

1. *Engineering division model XB-1A.*—Designed, constructed and tested by Engineering Division and made ready for production.

TYPE IX. ARMY AND COAST ARTILLERY OBSERVATION AND SURVEILLANCE THREE-SEATER

Preliminary study and design made.

TYPE X. CORPS OBSERVATION TWO-SEATER

1. *Engineering division model XB-1A.*—Designed, constructed and tested by Engineering Division and made ready for production. A contract for the production of forty airplanes let with the Dayton-Wright Airplane Co., June 28, 1920.

2. *Empire all-metal model.*—Contract for three experimental airplanes let with the Empire Metal Aircraft Corp., June 28, 1919. Supervision and inspection maintained by the engineering division. The first airplane ready for delivery.

3. *Lepere U. S. A. C-11.*—Engineering division installed the Moss supercharger in this airplane, resulting in the attainment of remarkable performances.

TYPE XI. DAY BOMBARDMENT

1. *Engineering division model U. S. D-9A.*—Developed and ready for production.

TYPE XII. NIGHT BOMBARDMENT (SHORT DISTANCE)

1. *Martin bomber.*—Designed and constructed by Glenn L. Martin Co. and tested, developed and made ready for production by Engineering division. A contract was let June 9, 1920, for the construction of twenty airplanes of this type by the Glenn L. Martin Co.

TYPE XIII. NIGHT BOMBARDMENT (LONG DISTANCE)

1. *Engineering division model Barling.*—Designed by engineering division. A contract for the construction of two experimental airplanes of this type was let June 23, 1920, with the Wittemann-Lewis Co. This type uses six Liberty 400 hp. 12-cylinder engines and carries a useful load of approximately 18,000 lb.

TYPE XIV. TRAINING (AIR-COOLED ENGINE)

1. *Huff-Daland model.*—Contract for the construction of three experimental airplanes let with Huff-Daland Co. June 4, 1920.

2. *Elias model.*—Contract for construction of three experimental airplanes let with G. Elias & Bros. June 28, 1920.

3. *Engineering division model XT-1, XT-2.*—Preliminary layout and mockup made by engineering division.

The above types will use the Lawrence 140 hp. radial air-cooled engine now being developed for the engineering division.

TYPE XV. TRAINING (WATER-COOLED ENGINE)

1. *Engineering division model XT-3.*—Design and experimental airplanes being built by engineering division. The Liberty 220 hp. 6-cylinder engine used in this type.

2. *Vought model VE-7.*—This type designed and constructed by Lewis & Vought Airplane Co. and tested, developed and made ready for production by the engineering division.

3. *Curtiss JN Models.*—Designed and constructed by Curtiss Airplane Co. and tested, developed and made ready for production by the Engineering Division.

TYPE XVI.—SPECIAL HIGH-ALTITUDE ARMY AND COAST SURVEILLANCE

Study and design by Engineering Division incorporating Moss superchargers and air-tight compartment features.

MISCELLANEOUS TYPES

1. *Engineering Division Model VCP-R.*—Official U. S. Government entry in the Gordon Bennett international cup race. The Model VCP-1 modified to take the Packard 550 hp. engine. Speed of 190 m.p.h. anticipated.

2. *Engineering Division ambulance.*—A DH-4 airplane modified to carry two litters and the pilot and surgeon for emergency transportation by air.

3. *Engineering Division messenger.*—For dispatch service. Designed by Engineering Division, using Lawrance 3-cylinder 60 hp. engine. Contract let with Lawrence Sperry Aircraft Co., April 14, 1920, for the construction of five experimental airplanes of this type.

4. *Miscellaneous.*—Exhaustive study and various layouts of airplanes to be constructed of metal.

STRUCTURES AND AERODYNAMICS

Stress calculations and theories.—Stress analysis made and reports issued on structures of twenty-six completed or projected airplanes.

A stress analysis book, a designer's handbook and design charts were compiled and distributed to airplane designers.

Static testing and methods.—Static load tests and reports made on numerous miscellaneous equipment. Static load tests and reports made on eleven types of airplanes.

Wind tunnel tests.—Thirteen complete models were tests for stability and aerodynamic properties in wind tunnels. Also numerous wing sections and miscellaneous equipment.

PROPELLERS

Variable and reversible pitch propellers.—Invented by Seth Hart and constructed, tested and developed and made ready for production by the Engineering Division.

Metal propellers.—Various types constructed by Dicks-Lattrell Co., Standard Steel Propeller Co., and Ionia Steel Propeller Co., being developed and made ready for production by Engineering Division.

Micarta propellers.—Designed and tested by Engineering Division. Built by Westinghouse Electric & Manufacturing Co. Being developed and made ready for production by Engineering Division for several types of airplanes and engines.

Thrustmeter, wind tunnel research and whirling tests being conducted by Engineering Division.

POWER-PLANT SECTION

Liberty engines.—A large amount of experimental and development work was carried on during this period with the Liberty engines. A vacuum oil pressure control, a new valve tappet adjustment, and the inverted Stromberg carburetor were developed.

A contract was entered into with the Packard Motor Car Co. for assembling a DH-4 airplane and improving the Liberty engine.

Hispano-Suiza engines.—A large amount of experimental and development work on these engines was accomplished during this period, resulting in the improvement of design and functioning of this engine.

Miscellaneous engines.—Numerous tests were made on miscellaneous engines, both of American and foreign design and manufacture.

A contract was entered into with the Packard Motor Car Co. for the design and construction of three types of engines: (1) An 8-cylinder, V type developing around 180 hp.; (2) a 12-cylinder, V type, developing around 300 hp.; and (3) a 12-cylinder, V type, developing around 550 hp. All types were received and tested. Engineering Division model W, an 18-cylinder engine of 700 hp., was completely designed by the Engineering Division and practically all parts were started in construction. Some of the parts manufactured by the Engineering Division and some by outside manufacturers.

Air-cooled engines.—A large amount of experimental work and study was devoted to air-cooled engines. Exhaustive tests conducted on several existing types.

A 3-cylinder horsepower engine, designed and manufactured by the Lawrance Aero Engine Corp., was tested and improved for production. A contract was let with the Lawrance Aero Engine Corp. for the design and construction of a 9-cylinder 140 hp. air-cooled engine.

A competition for the design and construction of a 9-cylinder 350 horsepower radial air-cooled engine was conducted, and two contracts were let, one with the Wright Aeronautical Corp. and one with Fred A. Weinberg.

ACCESSORIES

Numerous tests and reports made covering power-plant accessories, such as pistons, piston rings, spark plugs, carburetors, magnetos, fuel systems, and cooling systems.

Research.—Exhaustive tests in an altitude chamber conducted in cooperation with Bureau of Standards on various engines.

Superchargers.—Extensive flight tests were conducted with the Moss supercharger installed on the Liberty engine in a Lepere airplane. During these tests the world's altitude record was broken.

Installations.—Improved methods of engine installations in airplanes constructed for the government were compiled and included in Handbook of Instructions for Designers and published for the information and guidance of the aeronautical industry.

EQUIPMENT SECTION

Leak-proof tanks.—During this period sixty-five experimental leak-proof tanks were tested by the equipment section, resulting in specifications and illustrated drawings for production purposes.

Instruments.—Numerous aeronautical instruments, including a gasoline-level gauge, a gyroscopic compass, an air compass and oxygen apparatus were developed and made ready for production.

Electrical.—Numerous electrical apparatus were tested and developed and made ready for production, including an electrical tachometer, engine-driven generators for heating, lighting, radio and ignition.

Electrical engine starters were thoroughly tested, developed and made ready for production.

Flotation gear.—Flotation gears, to be installed on land machines, to provide against forced landing in water, were designed, tested and made ready for production.

Field shelter and equipment.—Several types of tent hangars were contracted for and erected for service tests.

A field engine cranker was designed, built and put into use.

A field lighting system was designed and made ready for use on semipermanent and permanent landing fields where night flying is done.

Parachutes.—A large number of test parachute drops were made, resulting in a design of parachute for use by all flying personnel.

Radio.—Exhaustive tests and development accomplished with wireless telephone and telegraph apparatus and their installation and operation in aircraft.

Photographic.—Both air and laboratory tests made on various types of cameras and the methods of installation and operation in aircraft improved.

MATERIALS SECTION

This section has conducted numerous investigations and laboratory tests on all raw materials that go into the make-up of aeronautical equipment and prepares specifications for raw materials. This work is carried on by the following subsections, namely: Chemical, metallurgical, textiles and rubber, physical testing, woods, plywoods, glues, etc.

ARMAMENT SECTION

Machine guns.—The Ordnance Department is responsible for the development and design of all types of machine guns. The armament section, however provides for the proper installation and modification to adapt these guns for their use. This has been accomplished with the following machine guns; namely, the Vickers, 11 mm., .30 cal., the Browning, .30 cal. and .50 cal., the Marlin, .30 cal.; and the Lewis, .30 cal.

Flexible mounts.—Extensive work accomplished upon the design, construction and development of new types of mounts for flexible guns.

Design has been made and a model constructed for mounting the .50 cal. Browning machine gun as a flexible gun.

SYNCHRONIZING DEVICES

Nelson-gun control.—During this period the Engineering Division accomplished a satisfactory installation and operation of this mechanical gun control.

An electrical synchronizing device was devised and tested with satisfactory results.

Cannon.—A 37 mm. automatic Baldwin cannon was satisfactorily mounted and operated from aircraft.

A 2.95 in. Mountain gun was installed and tested in a Martin Bomber with satisfactory results.

Bombs and bombing equipment.—Satisfactory progress made in proving the installation and operation of bombing equipment.

TECHNICAL DATA SECTION

This section receives, sorts and otherwise prepares for distribution all technical data distributed by the information group, Air Service, for information and guidance of the mili-

tary and civilian aeronautical organization of the United States.

FLYING SECTION

This section made approximately two thousand test flights during this period in determining the air performances of aeronautical equipment.

In addition to the work accomplished for purely military purposes as outlined above, the Engineering Division has given an infinite amount of assistance to the aeronautical industry of this country and for the promotion of commercial aeronautics.

Work accomplished from July, 1920, to Jan., 1921

AIRPLANES

PURSUIT TYPE

Engineering division model PW-1.—Experimental construction started at McCook Field. This airplane to be of metal construction and built around the Packard 300 hp., 12-cylinder engine.

Contract let for experimental airplanes of metal construction to be built around the new 350 hp. Radial air-cooled engine developed during last fiscal year.

Delivery of Thomas-Morse Model MB-3 and Ordnance Engineering Model Orenco D airplanes being made and tested for service use.

ATTACK TYPE

Contract let for single-seater armored attack airplane of metal construction to be built around the Wright 300 hp. Cannon engine developed last fiscal year.

OBSERVATION TYPE

Engineering division model C. O. 1.—An internally braced monoplane of metal construction built around the Liberty 400 hp., 12-cylinder engine started at McCook Field.

Engineering division model C. O. 2.—An experimental biplane of metal construction built around the Liberty 400 hp., 12-cylinder engine started at McCook Field.

XB-1-A type.—Delivery being made of this type ordered on contract in June, 1920. These are being tested for service use.

BOMBARDMENT TYPE

Contract let for experimental construction of internally braced monoplane of metal construction to be built around the Engineering Division model 700 horsepower "W" engine.

Contract let for experimental construction of wings only of the three Liberty internally braced monoplanes of metal construction. The contract for complete airplanes of this type suspended until results of wing construction is determined.

Delivery of Martin bombers contracted for June 9, 1920, being made. These airplanes are being tested for service use.

MISCELLANEOUS TYPES

Engineering division VCP-R, with 600 horsepower Packard engine, completed, tested and entered in the Pulitzer race. This airplane won the race with a speed of 188 miles per hour.

Messenger airplane.—Delivery being made of this type contracted for last fiscal year. Tests indicate very satisfactory results.

Exhaustive tests and construction being continued of metal airplanes.

Ambulance airplane.—A Curtiss "Eagle" airplane built around the Liberty 400 horsepower 12-cylinder engine is being converted for ambulance purposes.

POWER PLANT

Engineering division model 700 horsepower "W" engine.—This experimental engine is being assembled and made ready for tests.

Model 350 horsepower radial air-cooled engine.—These experimental engines are being assembled at factories and made ready for tests.

Model Wright 300 horsepower cannon engine.—Sufficiently satisfactory results obtained to warrant the installation of this engine in a single-seater armored attack airplane.

Packard models, 8-cylinder 160 horsepower, 12-cylinder, 300 horsepower and 12-cylinder 600 horsepower engines.—Being tested, developed and made ready for production.

Lawrance 9-cylinder 140 horsepower air-cooled engine.—Being assembled at factory for tests.

ACCESSORIES

Tests and development of accessories enumerated in program of last fiscal year being continued.

PROPELLERS

A steel reversible pitch propeller was built and is being tested.

Micarta propellers for Liberty engines being delivered and tested for service use.

EQUIPMENT

Leak-proof tanks, instruments, electrical apparatus, parachutes, radio and photographic apparatus, having passed experimental stages during the last fiscal year, are being produced for service use.

Development and tests being continued on all this equipment, with improvements of design, construction and operation in mind.

Armament.—The 2.95 inch cannon mounted in a Martin bomber is receiving further tests and being made ready for installation in service machines.

The electrical synchronizer has received further tests and is being made ready for production.

The 37 mm. automatic Baldwin cannon with flexible mount will be installed on service airplanes.

Tests and improvements continue on all armament apparatus outlined in program of work for last fiscal year.

MATERIALS SECTION

An armored airplane, capable of resisting the armor-piercing bullet at 2,400 foot-seconds velocity, has been developed.

Steel specifications for airplane construction have been improved and simplified.

Program of Work from Jan. 1921 to July, 1921

During these six months a strict and thorough supervision and inspection will be maintained over all airplanes, engines and aeronautical equipment now undergoing experimental design and construction.

Exhaustive tests and necessary modifications and improvements will be carried on to prepare this equipment for production, manufacture and service use.

An experimental order for a three-seater armored ground attack to be let. This airplane to be constructed of metal and to carry eight or nine machine guns and a 37 mm. cannon.

An experimental order for a night bombardment airplane with three Liberty engines to be let. This airplane is to be constructed of metal and of internally-braced monoplane design.

The Engineering Division will carry on the study and design of a 1,000 hp. aeronautical engine.

The Moss supercharger being built under contract with the General Electric Co. will be installed on the Liberty engines of the Martin bomber and other suitable service types of airplanes.

Suitable apparatus for carrying 2,000 and 3,000 lb. bombs will be installed on the large bombers.

Variable and reversible pitch propellers and Micarta propellers will be constructed in quantity and furnished for service use.

The Engineering Division, in addition to the work outlined above, will continue a thorough survey of all aeronautical equipment now on hand as a result of material accumulated during the war, and devise methods by which this material can be used up economically.

Successful Test Flights

The Aviation Repair Depot at Montgomery, Alabama, is to be congratulated on the excellent work being done at that station. Of five planes assembled at that station and flown in a test flight of one half an hour and then taken on a six hundred mile trip not a single fault or defect was found in any plane. The trip taken was to Carlstrom Field. The country over which the planes were taken is about the worst to be found in the United States. For miles landing places were not to be found. All the motors had been repaired and overhauled at the depot. They all functioned perfectly and gave each pilot a great feeling of confidence over the worst forests in Florida. The success of the flight is attributed to the co-operation extended on the part of the personnel at the Aviation Repair Depot. Everything possible was done by them to make the ferrying of the ships from their station to Carlstrom Field successful.

Gathering Aircraft Data

The National Aircraft Underwriter's Association is collecting its aeronautical statistics on the following basis:

Name of Plane.

Type:
1. Sea or land
2. Mono-, Bi-, or Triplane
3. One, two or more motors.
4. Metal or fabric covering
5. Monocoque or built-up fuselage
6. New and second-hand
7. Advertised landing speed
   - Under 30 miles.
   - 30 to 40 miles.
   - 40 to 50 miles.
   - 50 and over

Use:
1. Classifications:
   - Private.
   - Business.
   - Other special usage.
2. Contents
   - A. Mail.
   - B. Persons.
     - Freight.
     - Persons and Freight.
     - Mail.
     - Without any
     - Other contents not yet mentioned.
3. Special Use
   - A. Bus Service.
     - Business delivery
     - Other business purposes (not delivery and not mentioned hereafter).
     - Instruction—School.
     - Pleasure
     - Inspection, patrol work, etc.
     - Jitney
     - Other not specified uses
   - B. Exhibition
     - Advertisement
     - Photographing
     - Stunt.
     - Other not specified uses.
4. Form of use
   - Schedule flying (irrespective of weather)
   - Single trip flying

Territory:
1. State
2. Exclusively over land
   - Exclusively over water
   - Over both

Pilots Grading

In regard to losses, the information requested is as follows:

Fire
- Hangar fires.
- Air fires.
- Field fires.
- Fires originating internally
- Fires originating externally.

Theft
1. Theft of machine.
   - Theft of parts.
   - Damage to machine by theft.

Collision
1. Location
   - Forced landing in home field.
   - Forced landing in other established fields.
   - Forced landing in any other place.
   - Not forced landing in home field.
   - Not forced landing in any other established field.
   - Not forced landing in any other place.
   - Collision in air with plane.
   - Collision in air with other objects.
2. Causes:
   - Losses due to weather conditions.
   - Losses due to starting in small field
   - Losses due to starting in congested fields.
   - Losses due to landing in small fields.
   - Losses due to landing in congested fields.
   - Mechanical defect of plane.
   - Mechanical defect of motor (except propeller)
   - Mechanical defects of propeller
   - Lack of fuel
   - Lack of other supplies
   - Reasons not otherwise specified
3. Time
   - Collision at beginning of trip
   - Collision at end of trip
   - Collision before reaching destination.

Stranding and Sinking:
- Plane improperly moored.
- Plane beached.
- Forced landing.
- Collision with other craft.
- Reasons not otherwise specified.

Windstorm:
1. Cyclone or tornado.
   - Heavy wind.
2. Loss in field—secured
   - Loss in field—not secured.
   - Loss in temporary hangar.
   - Loss in permanent hangar

Starting Torque on Aviation Engines

To determine the starting torque on Liberty, Hispano-Suiza and other aviation engines with a view to obtaining power starter requirements the Engineering Division of the Air Service, at McCook Field, conducted a series of tests. The results are reproduced herewith from the Air Service Information Circular No. 126.

Appended herewith is a table of the torque required to start the reciprocating parts of an engine moving. It is recommended, however, that in the design of power starters a factor of safety of at least three on the torque available be adopted.

The engines were mounted on an electric dynamometer and, with the engine cold, motor torque was applied gradually until the crank shaft of the engine started to move. This torque was noted. The trials were repeated with open and closed throttle.

Throughout these tests U.S.A. Specification No. 3501 (paraffin base) oil was used. The viscosity, by the Saybolt method of this oil is 85 seconds to 90 seconds at 212 degrees F.

Results of Test

AVERAGE STARTING TORQUE, POUNDS-FEET

Engine	Number cylinders	Rated horsepower	Normal speed	Bore (inches)	Stroke (inches)	Number of engines tested	Number of trials	Starting torque, pounds-feet: Throttle open: Maximum	Throttle open: Average	Throttle closed: Maximum	Throttle closed: Average
Liberty	12	400	1,700	5.00	7.00	2	6	150	124	156	143
Hispano-Suiza	8	300	1,800	5.51	5.91	6	6	109	102	101	96
Liberty	8	213	1,700	5.00	7.00	2	6	132	105	135	110
Packard	8	160	1,600	4.75	5.25	1	2	119	82	87	77
Do	12	236	1,800	4.75	6.50	1	1	185		200	
Rausie	6	175	1,650	5.00	5.00	1	2	116	116	147	146
B. M. W.	6	185	1,400	5.33	7.08	1	3	150	129	153	145

Average air temperature, 73° F.

Ed. Note. These results also have an important bearing on the question of starting an engine by the propeller on a drive.

America's First Model Airway

Prophecy of aeronautic progress in 1921 in the face of existing business conditions, would be idle, but what will prove to be a vital milestone in the progress and development of both commercial and military aeronautics will be the creation and establishment of America's first model airway from Washington, D. C., to Dayton, Ohio, during the early months of 1921.

The establishment of well organized air routes throughout the country is as essential to a well balanced system of national defense as is the development work on the aircraft itself. The ocean of the air must be explored, and charted just as unknown lands and oceans, so that navigators may, with ease make their way without loss of time or danger across vast expanses of territory in peace or war. The installation of an airway entails the location of landing fields with all accessories, including radio direction finding, radio communication, aids to night navigation, housing and maintenance of equipment. It is undoubtedly true that with properly established airways of this kind, cross country flying, night or day, in good or bad weather, will be safer than auto touring by road, and that with the development and perfection of the machine itself, will in time surpass in speed, comfort and safety, the modern comforts of transports.

These air routes will provide a net work whereon the units of the National Guard and the organized Reserve can be placed. However, these highways of the air will not be usurped by the Air Service but they will be open, under legislative restrictions, to all commercial operators who will receive all the benefits and conveniences of such an organization. Therefore commercial aeronautic interests will be fostered.

One vital point of value in the creation of national airways is in convincing the public by their operation that aviation

The Army Air Service is unable of course to purchase any land or make any expenditures in connection with the creation of this airway but can provide such equipment as is available for getting the route established. The small expense attached to the installation of this route naturally should fall on those who will receive the direct benefits of its existence and operation such as the communities, organizations, and individuals along the route. The Army Air Service will gladly supply all the advice, specifications, and information relative to the creation of the airway. This information would pertain to such things as landing fields, radio, hangars, and even might include the sending of qualified officers to superintend or consult. Therefore Chambers of Commerce, Clubs, Lodges, and all civic or fraternal organizations together with public spirited citizens should take immediate action to install a landing field, by calling on the Army Air Service and by organizing volunteer labor to put the project through. Boy scouts can assist very materially in this program.

Just as the Braddock Trail, the S. S. *Great Eastern* and the Clinton locomotive are historical high water marks, just so will the creation of America's first airway go down in history and the reflected glory of the event will be the heritage of each and every man that assists manually, financially or otherwise in its installation. Certain terminals on the airway will have gasoline, oil and spare parts for both government and civilian aircraft. Charts will be made of the entire route at the request of the Army Air Service and also a photographic map of the route will be prepared. Oblique aerial photographs of every city, landmark and landing field will be taken and arranged into such form as to provide a guide to the route. Copies of these books can be signed for at one end of the route and turned in at the end of the journey. Fliers along

MAP OF THE PROPOSED MODEL AIRWAY FROM WASHINGTON, D.C., TO DAYTON, O.
(Prepared by the U. S. Army Air Service)

control is a matter of Federal rather than State legislation. The operation of the model airway for but a very short time would definitely convince the public on this point.

The model airway will become the first unit in a comprehensive system of airways throughout the United States which will be started under a policy formulated by the Army Air Service and which will be guided in its organization by the experience gained from the establishment and operation of the model airway.

The model airway as chosen is extremely well suited to the purpose of serving as a basic guide in this expansion program. Almost all of the natural problems attendant to successful air navigation are met on this airway which is one that will always be needed. Incidentally it connects Washington, D. C., with the Air Service Engineering Division Headquarters. In the course of this route appear mountains to be passed over, varying climatic conditions, and terrain of almost every type and character.

the route will be in constant radio communication with each other and with the various ground stations and in case of fog or clouds will be directed along the route by radio. Should a group of commercial ships desire to negotiate the route unequipped for wireless, then an airplane so equipped can be dispatched with them along the route and they can "follow the leader" in perfect safety.

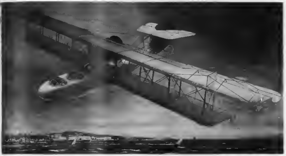
A system has been devised for marking the landing fields along the route for purposes of identification and will serve as an aid to navigation. Each state is being divided into one hundred parts from West to East, and lettered alphabetically North to South, each letter representing a distance of 30 miles. A field in the northern part of Eastern United States marked O-55-B would be in Ohio, about half way across the state, and between 30-60 miles below the northern border. Since commercial craft will probably negotiate a 30 mile distance in slightly over 15 minutes locations by this system are sufficiently close together for navigating purposes. More minute

UNANIMOUSLY RESOLVED PILOTS AND OWNERS OF COMMERCIAL AIRLINES —

That

THE **AEROMARINE** NAVY H-S-2-L FLYING BOATS AT THEIR PRESENT LOW PRICES AND WITH THEIR LOW OPERATING COST OF ABOUT **$16.00** *PER FLYING HOUR* (COVERING FUEL, PILOT AND MECHANIC) AND THEIR CARRYING CAPACITY OF SIX, ALLOWING A POSSIBLE REVENUE OF FROM $250. TO $300. *PER FLYING HOUR*

ARE THE BEST AVIATION BUY IN AMERICA TO-DAY



Aeromarine Navy HS2L Open Cockpit—Model 85

PRICE $6500, IMMEDIATE DELIVERY .

This is the celebrated HS2L Navy Coast Patrol Flying Boat converted to meet the requirements of aerial photography, forest patrol, timber scouting, surveying and mapping, locating schools of fish for commercial fisheries, fire patrol, etc.

To encourage commercial aviation the U. S. Government has chosen **The Aeromarine Engineering & Sales Company** as the channel through which you may be allowed to purchase these beautiful boats at less than one third of what it cost to build them.

The Aeromarine Company has invested hundreds of thousands of dollars in successfully operating flying boats for commercial purposes - All of this valuable experience is at the disposal of companies operating flying boats - The supply of boats is limited - Send for booklet and further information to-day -

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***Price** . $6, delivery*

Aeromarine- eat, Enclosed Ca ine

***Price** . $9 delivery*

THE CANADIAN GOVERNMENT LAST JULY SELECTED ONE OF THESE NAVY BOATS OV ALLIED AIRCRAFT TO MAKE THE LONG FLIGHT BETWEEN COCHRANE AND HUDSON BAY

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details will be provided in certain subdivisions of the system at or near landing fields and in the laying out of signs and letters.

Some of the cities along the model route are as follows with their identification marked opposite

MARYLAND		Senecaville	O-78-E-8
Cumberland	M-17-A	Shadyside	O-96-E-6
Carlos	M-13-A-4	S. Zanesville	O-65-E
Eckhart Mines	M-14-A	Springfield	O-24-E
Friendsville	M- 3-A	St. Clairsville	O-92-E
Frostburg	M-13-A	West Jefferson	O-37-E
Kensington	M-55-B	Yellow Springs	O-22-F
Mt. Savage	M-15-A-1	Zanesville	O-66-E
Rockville	M-53-B	VIRGINIA	
Vale Summit	M-15-A-3	Falls Church	V-81-B
OHIO		Ft. Meyer	V-82-B
Barton	O-94-E-3	Herndon	V-79-B
Barnesville	O-85-E	Leesburg	V-76-A
Bellaire	O-96-E-5	Rosslyn	V-83-B
Bethesda	O-88-E	WEST VIRGINIA	
Bridgeport	O-96-E-4	Benwood	W.V-40-B-5
Byesville	O-76-E	Cameron	W V-43-B
Beallsville	O-89-E	Charlestown	W V-98-D
Buffalo	O-44-E	Elm Grove	W V-42 B
Cambridge	O-75-E	McMechen	W V-40-B-6
Cedarville	O-24-F	Moundsville	W V-40-B-7
Cumberland	O-74-E	Paw Paw	W V-85-C
Columbus	O-44-E	Wheeling	W V-40-B-4
Dayton	O-15-F	PENNSYLVANIA	
Granville	O-54-E	Brownfield	P-14-F-7
Grove City	O-41-E	Confluence	P-20-F
Hebron	O-55-E	Elk Lick	P-25-F
London	O-33-E	Fairchance	P-14-F-9
Lore City	O-78-E	Hopwood	P-15-F
Martins Ferry	O-96-E-3	Masontown	P-12-F
Neffs	O-94-E-5	Millsboro	P-10-F
Newark	O-56-E	New Salem	P-13-F-6
New Concord	O-72-E	Rices Landing	P 9-F
Osborn	O-19-E	Smithfield	P-12-F-9
Pataskala	O-51-E	Uniontown	P-14-F-6
Philo	O-68-E	Waynesburg	P- 6-F
Quaker City	O-82-E	Greensboro	P-11-F-8
South Charleston	O-28-E	Ft. Marion	P 11-F-9

Fairfax, Va., has an area adaptable for a landing field one quarter mile southwest of town This field should be put in shape immediately by the cooperation of the various local civic bodies. A large sign for minute identification will have to be laid out near the field

Herndon, Va., has a good area for a landing field just south of the town. The name of the town should be laid out in as large white letters as is permissible on the ground near the field

Leesburg, Va., has a space available for a landing field just southeast of town A large marker bearing the letters "LEESBURG, VIRGINIA", should be placed near the field.

Bluemont, Va., close in toward the Blue Ridge Mountains, should prove an important link in the airway, and has space for a landing field northeast of the city The town itself is on a slope facing the northeast.

Berryville, Va., just across the Blue Ridge from Washington, has an adaptable field just east of the town.

Charlestown, W. Va., has a landing field available north of the race track north of the town.

Rockville, Md., has a good landing field just west of the town but the stumps should be removed from the center of this field

Romney, W. Va., situated in hilly country, has a fair landing field on the river about two miles west of town near a small island in the river. A small emergency field is also available bordering the west section of the town.

Keyser, W Va , has a small landing field available for emergency landings about one mile east of town on the river. Keyser is situated in extremely mountainous country and for that reason is an important link in the airway. This town is distinctly marked by its extensive railroad yards.

Cumberland, Md., is easily distinguishable by a large gap in the mountains north of the town. There is a good two-way landing field southwest of the town on the river. The town itself is down in a basin on the river and surrounded by large mountains and peaks on all sides.

Paw Paw, W Va , lies just to the west of the hilly country and is distinguishable by a large red building with a black roof. There is a good landing field about one mile north of town on a bend in the river that should be developed.

These points are all within the area of America's model airway and they should immediately get together and appoint a local landing field committee to deal with the Army Air Service in putting their own local necessary improvements into existence at once America's model airway must be finished by May, 1921

Hagerstown, Md , and Moundsville, W. Va , have already set a pace that will be hard to beat both in cooperation and preparation. Each has come forward with available landing fields and preparations are now being made for erecting the hangars and gas and oil stations, and marking the fields.

Radio School for Air Service

The use of radio communication, both telegraph and telephone, on the military airplane is perhaps the latest application of radio science, increasing tenfold the usefulness of the airplane and already influencing the design of military aircraft. Airplanes have been called the eyes of the army but eyes without means of instantly communicating images and impressions registered upon the retina would find but a limited sphere of application It is in the performance of this function that radio finds such an important place in military aeronautics. The dots and dashes of the Morse code transmitted from the trailing aerial of the airplane carry to the ears of the artillery battery commander the correction for each shot fired, enabling him to group his hits on an invisible target with a degree of accuracy as great as is possible when the target can be seen, or bring to a waiting general news of enemy troop movement observed from the air

Squadrons of Attack Pursuit Planes can be maneuvered in flight by means of the wireless telephone from the airplane of the squadron commander or from the ground easily as a company of infantry is handled By the same means, a machine engaged in aerial combat and outnumbered may call for assistance

Bombing planes lost in the fog or darkness are directed unerringly to the home airdrome by the radio direction finder and airplanes without pilots, controlled entirely by radio, are already a reality

The Air Service of the Army, realizing the importance of this newest phase of radio, has established a school for the training of personnel to install, operate and maintain the radio equipment of airplanes at all the flying fields throughout the country. Radio engineers and operators, as well as experienced amateurs, may qualify for attendance at this school upon application to any army recruiting officer or to the office of the Chief of Air Service, Washington, D C

An Aerial Terminus of the Future

Something very unique in the way of a terminal station for future traveling is suggested in *Flight* of Jan. 6. It is a picture by Roderic Hill showing an aerial terminus of the "White Moon Line", raised aloft over a seaport. It is not a flat aerodrome situated on the surface, but is a huge circular structure which towers far above the tallest buildings of the city On its topmost circumference, platforms swinging on a circular railroad bed are carried by two rotating arms on which aero liners alight and from which they take off On the left of this great tower is a passenger elevator with two cars carrying passengers to and from the embarking level Inside this structure is a huge elevator for lowering the aero liners for refitting and repair, and in its mysterious depths we can picture workshops lit by flickering arc lamps, where hundreds of mechanics work busily day and night. With such termini as this, sea captains of the future will be looking up at air captains as each in his respective craft draws near to exchange or deposit the cargo in his care, and thus it will be that the dreamer of today will behold the fulfillment of his vision.

The Klemin Amphibious Gear

By Donald W. McIlhiney

The subject of providing a gear to permit airplanes to land as either sea or land has received a great deal of attention abroad and was the subject of a government competition last year Very little work has been done in this country until recently

Alexander Klemin & Associates, Consulting Engineers, New York, have developed a gear that fulfills this purpose.

The device which was built with considerable skill and good workmanship by G. Elias & Bro , Inc , Buffalo, N. Y., has been fitted to a Curtiss MF flying boat and the boat was taken off the land several times and landed on the rough waters of Lake Erie and also successfully flew from the water several times. Tests were recently conducted at Buffalo under the supervision of the Navy Department, which tests the device successfully passed.

The gear consists of two main parts, the landing gear proper and the tail skid, both of these parts are retractable. The designers were somewhat handicapped by the fact that the hull of the MF boat is fitted with projecting fins and this feature made it necessary to have a large overhang in the wheel supports In addition some internal strengthening was required to permit the hull structure to take the loads encoun-

KLEMIN AMPHIBIAN GEAR READY FOR LANDING OR TAKE-OFF FROM THE GROUND

tered when landing on a flying field instead of on the water, for which the hull was designed.

The landing gear proper is supported by an axle of large diameter passing through the hull back of the passenger seats and in front of the gas tank Due to the presence of the fins, it was found necessary to have this axle project a considerable distance from the side of the hull In a hull designed to be fitted with this gear, the overhang would be unnecessary. The overhang of the axle is braced to the sides of the hull by two faired steel tubes, running to points near the top of the hull. Inside the hull the axle is fitted with a gear wheel segment, which is acted on by a worm gear fitted to a shaft with a control wheel at the top A drum is also attached which carries to the tail skid operating wires.

There is a single wheel on each side of the hull. Each wheel is carried by two "A" struts, one on each side.

The shock absorbers are divided in four parts. The ends of the wheel axle are fitted into cross pieces. The shock absorber cords are wrapped around this cross piece and the head of the "A" struts. The struts are keyed to the main axle, so that when the worm is operated by the control wheel, the wheels with their struts are turned up along the side of the hull. To take the horizontal loads on the wheel, a steel tube "V" is attached to the base of the struts at the open end, and

KLEMIN AMPHIBIAN GEAR FOLDED UP READY FOR TAKE-OFF OR LANDING ON WATER

to a slide on the edge of the fin at the apex. When the wheels are down in the position for land work, the apex of this bracer "V" rests against a stop on the edge of the fin The stop is, in turn, braced to the side of the hull by a faired steel tube, and a wire cable.

The tail skid and its mechanism, which were designed by Mr Stupar, Superintendent of Construction, G Elias & Bro., Inc , are attached to a fitting mounted on the lower end of the stern post. A special stern post fitting was designed for the purpose, which distributes stress over a considerable portion of the after end of the hull. This consists of a steel tube 1¼ in diameter, 14 gauge, reinforced at the point of greatest bending moment with a 1/8 in. wall steel tube, which is held in place at a point near the center in a fitting which allows it to revolve upon its axis, in order to provide for side thrust.

The fitting on which it is mounted is itself fastened to the tail post fitting in such manner as to provide for vertical movement The lower end of a short steel strut is also hinged to this fitting at its lower end. The upper end is held rigidly by a specially designed hook which engages a pin through the top of the strut at either side and which in turn is held by a bolt passing entirely through the rear end of the hull, transmitting the stress to the stern post fitting by means of extensions provided for the purpose. The upper end of the tail skid is held to this strut by means of six wraps of shock absorber cord

which provides the proper resiliency when landing on the ground.

The tail mechanism is so connected with the drum on the main shaft that it operates in conjunction with the landing gear so that they both retract simultaneously, and are easily operated by the pilot from the cockpit in 15 sec time. This is a big feature, as some of the gears designed heretofore required a separate operating for each component.

The retractable tail skid also prevents this component from adding any unnecessary resistance when the boat is gaining planing speed on the water. Alexander Klemm & Associates have studied the application of this gear to a number of flying boat hulls, also to twin ponton machines; and have applied for patents on a variety of forms as well as on the fundamental principle. They are offering to apply such a gear to any flying boat or twin pontoon machine that builders or owners of such planes might be interested in.

Air Bombing and Future Warfare

In his annual report for 1920, Major General Cox, Chief of Coast Artillery, and, consequently, in charge of the defense of seaports, does not shrink from pointing out the obvious fact, that, by reason of the increasing development of military aircraft, the security of the United States can no longer be guaranteed from attack. While the limited radius of the airplane today gives the thought of attack from that source a somewhat negligible quantity, the rapid development of aircraft of all kinds should serve to dispel any prolonged feeling of security in the part of the United States. The recent successful trans-Atlantic flights can be regarded as ample and sufficient warning of what may be possible, at least in the future.

In line with the food for thought contained in General Cox's report is an article on "Air Bombing of Industrial Plants", by Colonel William A. Borden, Chief of Aircraft Armament Division, office of Chief of Ordnance, which appeared in "Army Ordnance" for Nov.-Dec., 1920.

An editorial note preceding this article reads as follows: "The outstanding lesson of the World War was the controlling influence of munitions power, in contradistinction to man power. Accordingly, it is highly probable that the strategy of future wars will turn largely on attempts to destroy or diminish munitions power by attacks upon industrial centers. Of the methods available for this purpose, the most logical will undoubtedly, appear to be the dropping from airplanes of huge bombs containing a ton or more of high explosives and capable of effecting complete effacement of the factories attacked."

Colonel Borden reminds us that "France, England, and other European countries were, during the war, subjected to numerous aerial attacks in which the main munitions used were bombs and although bombing was not highly developed even when hostilities ceased, considerable material damage resulted from these air raids. The morale of the people in raided localities was lowered and the production of munitions and other necessary items of supply were interfered with and delayed."

"Although of the number of bombs dropped, only a very small percentage hit the mark, the destruction which it was possible to effect by bombing operations was recognized and elaborate systems of defense were instituted particularly in areas where important manufacturing activities were under way. Anti-aircraft equipment, searchlights, aviation patrols, and a system of warning signals were employed in the defense of these localities. The important machines in manufacturing plants were protected by armor plate shields, other parts of the plant were protected by earthen embankments and transverses to limit the effect of flying fragments, while various systems of camouflage were employed in screening the buildings. However, in spite of the extensive means of defense, bombing raids were becoming increasingly effective at the close of the war."

Describing briefly the general types as Demolition, Fragmentation, and Chemical, Colonel Borden points out that bombs weighing from a few ounces up to 1100 and 2200 lb. have actually been produced, and states that the development of others which will weigh more is contemplated. There seems to be no limit to the size of bombs, provided aircraft can be made large enough to carry and drop them.

There is, also, no limit to their destructive qualities. Of the general types referred to, the Demolition bomb, which, as the name implies, is meant to demolish, performs its work of destruction by the blast produced by the detonation. Such a bomb, weighing say 1000 lb., hitting almost any of the present day factories would completely wreck it; for it must be borne in mind, that these bombs have fuses which give a delay action, so that the explosion does not take place on the roof but the detonation occurs after the bomb has penetrated to the interior when it literally rends the building apart.

While Fragmentation bombs are, primarily, designed to wound or kill and are particularly effective against massed bodies of troops, as in billets, in columns, on convoys, they may also, of course, be used to supplement Demolition bombs in attacks upon manufacturing plants by reducing to fragments the wreckage of the building.

That the work of destruction may be made quite complete next comes the Incendiary bomb, which produces a conflagration.

If we add to the list of horrible possibilities the Poisonous gas bomb which would attack the personnel and not material, and would seek out the cellars, subways and similar places of once-supposed security, a faint suggestion, at least, may be obtained of what aerial warfare of the future may have in prospect.

Directly bearing upon the subject of this article by Colonel Borden, are reports that have appeared recently in the press regarding devices for luring aircraft away from cities, munition plants, etc., by means of luminous camouflage. "As early as May, 1916," the New York Herald points out, "certain plans were submitted to the British War Office, by Messrs. Dillon and Shellard. "While the Dillon and Shellard ideas were not adapted, they were pronounced as "meriting the sincere praise of the National Defense," and certain other methods grouping incandescent projectors were put into operation both by the French and English.

Also it may be noted in Feb., 1917, a United States patent was granted to Joseph A. Steinmetz of Philadelphia, for an invention the object of which "is to provide effective means for the destruction of aircraft by luring the hostile craft to a point where it can do little harm, being designed as lures to draw the attack of bomb dropping aircraft by simulating importance which they do not possess, and in arranging anti-aircraft guns for sending projectiles over the device at varying heights."

Air Mail to Germany

The steamship Mt. Clay, which sailed from New York on Feb. 19, carried the first letters that will be transported from Cuxhaven to Berlin and points in the Rhine district of Germany by airplanes.

The airplanes in question are capable of carrying from 375 to 425 lb. of mail matter and when the mails specially assigned for airplane service are placed in distinctive sacks before dispatch from New York the steamship officers will hand these bags to the German air mail officials as soon as the steamship arrives in Cuxhaven.

This airplane mail service will be continued from other vessels sailing from New York for Germany and the official bulletins of the Post Office Department from time to time will indicate what are the steamers to carry mails for ultimate delivery by airplanes in the Rhine district which includes Berlin among other prominent places in Germany.

Senders in the United States should specially mark any letters they desire sent by airplane, "Dispatch by airplane from Cuxhaven" and they will be given the benefit of this special service.

Bids on Amphibious Passenger Carriers

Bids are invited by C. P. Mayer, Bridgeville, Pa., in quantities of one, three and five, for an amphibious passenger airplane. The bids must be in by March 5. Specifications and conditions of bid can be obtained from Alexander Klemm and Associates, Consulting Engineers, 22 East 17th Street, New York City.

Flying Single and Twin Engined Airplanes*

By Squadron-Leader R. M. Hill

I feel that the following notes may prove of some use, in view of the fact that considerable experience with multi-engined airplanes has been allowed to accumulate without it being definitely brought together and analyzed, and that the best way to deal with their flying qualities is to compare them with those of the single-engined type, on which most of us have been brought up. However, this experience is still small compared to that of the single-engined type, which has formed the great bulk of airplanes that have seen service, and, so to speak, our stock-in-trade of flying knowledge.

Broadly speaking there is a similarity in the flying of all modern airplanes, but different types do need different handling and it seems to me that the widest gulf lies between the flying of airplanes which have more than one engine and those which have not. Having been brought up on the single-engined type, we might well be excused for thinking that our experience would be fully adequate to meet any contingency that might arise in the twin-engined type, but unless we use this experience with care, and select that only which is essentially applicable to the twin-engined type, there are pitfalls awaiting us. Later on I shall examine where this experience may help us, and more important, where it may lead us astray. I shall advocate an appeal to first principles, to which a pilot who flies with his head will instinctively revert in case of difficulty or bewilderment.

There is no doubt that the twin-engine type involves greater concentration in flying generally, simply because the pilot has more to look after, he has to cope with the difficulties met with every day in the single-engined type, but in addition he may meet with certain extra ones involved in the twin. Crashes on twin-engined airplanes gave rise to an exaggerated idea of their abnormal or dangerous behavior under certain conditions, the reason for which was but dimly realized and highly colored by quite unjustified feelings. If a calm appeal to reason had been made, these difficulties would have been seen to be perfectly normal, and only to be expected as inherent in the design.

Control and Design

Control may be roughly divided in two, control of the airplane, and control of the engine or engines.

I think that the key to the problem may be said to be the correct appreciation of how the two parts of the control react on each other. A failure to appreciate this, an attempt to treat subconsciously the two parts as separate involves grave confusion. It may be argued that a modern airplane is perfectly controllable without engine or engines, and that to make things simpler the airplane control may be thought of and analyzed alone. This statement is very misleading because it is so near the truth. Just where it falls short of the truth the difficulties commence, and in two main directions.

Firstly, when the power is completely shut off, the two elements of airplane and engine control are most nearly separate in the pilot's mind. Theoretically, with an airplane control complete in itself, a pilot might carry out any maneuver whatsoever, using gravity as a motor. Even if the airplane control could be regarded as complete in itself, it has not up to the present been made complete enough to meet effectively the control requirements of the airplane between all engines on and no engines on. It is obvious that in some airplanes these requirements are far more comprehensively met than in others, which means that the pilot can only regard this as a genuine difficulty which so far applied design has failed to overcome completely.

Secondly, in practice, especially with twin-engined airplanes, the airplane control is not complete in itself. Although recourse to it alone is necessitated in a forced landing with no engine or engines, in which case the best possible use has to be made of it, in actual fact most modern airplanes pass the accepted standard of controllability, when their control at low speeds is bolstered up by the use of engine to assist the rudder for instance. If the same standard were demanded without any engine, many airplanes would fail to come up to it. I know cases where Handley Page, Vickers Vimy and even Bristol Fighter airplanes have been extremely difficult to manage when approaching an aerodrome in rough weather without engines or even with engine throttled right down. The engines had to be applied solely to render the control effective. This is taken for granted by pilots and scarcely thought about.

Effect of Engine on Control

Even the most modern airplane engine may be controlled in two ways, firstly by the pilot, and secondly by mechanical faults, including faults in the petrol system. There will be two main considerations then; firstly, the effect of the engine on the airplane and the consequent movements of the controls as the pilot varies the power at will, or for some particular purpose, and secondly, the effect of sudden engine failure. If the pilot varies the power at will, he knows what he intends to do and therefore has a general idea of the effect on the airplane. The effect will be foreseen in the first case, may be violent and unforeseen in the second, and in general influences the airplane in four ways.—

(a) The presence or absence of slipstream will by affecting the tail, influence the longitudinal and lateral trim of the airplane.

(b) Simultaneously the position of the thrust axis or axes relative to the center of gravity will do the same when the thrust is varied.

(c) The engine torque varies with the horse-power developed, and naturally affects small single-engined airplanes to a much greater extent than large airplanes.

(d) The gyroscopic effect of a rotary engine may influence the airplane when it is maneuvered.

It will be seen from the above that reactions of a complex nature may be taking place, with all of which the pilot must deal.

The pilot may be carrying out a maneuver approaching the limit of his airplane control, when engine failure will suddenly introduce a completely new set of conditions involving possibly a total loss of control.

Effect on Single-Engined Airplanes

Before considering in detail the effect of engine on the control of multi-engined, it will be well to examine shortly that of single-engined airplanes. This must be done just so far as it affects the pilot and his power of control over his airplane. Take the four effects mentioned, the most important of course is that of the slip-stream on the tail. Assuming that the tail portion consists of a fin and rudder, tail plane and elevators, and that these are partly in the slip-stream, various and sometimes unsymmetrical loads will be applied as the power varies. The air of the slipstream is washed downward, and also given a rotary motion by the propeller. If it were possible to design the fin symmetrically in the slipstream, there would be no force on it. However, in practice, this is very difficult to achieve, owing to angle of incidence of the wings when landing and other considerations. Therefore in nearly all modern airplanes there is a tendency to turn one way with engine on, in some airplanes violently, in others less violently. Some of the former were provided with shock absorber on the rudder bar to relieve the pilot's feet of strain. It was found possible to neutralize some of this turning tendency by balancing the upper portion of the rudder on the R.E.9 airplane. It was thought that as the upper part of the rudder was clear of the slipstream, the balanced portion had a neutralizing effect owing to its angle when the slipstream was acting on the fin and the rest of the rudder.

It may be noted in passing that it has been observed that the smaller the diameter of the propeller, the more violent is the action of the slipstream on the fin. A Lion D.H.9A. was

* Abstract of paper read before the Royal Aeronautical Society

turned out with a propeller of a certain diameter, and exhibited a violent turning tendency. By increasing the diameter of the propeller, the turning tendency was reduced to reasonable proportions.

Again, the slipstream acts on the tail plane. Most modern airplanes are provided with a moveable tail, which is specially necessary on airplanes with high-powered engines, for the purpose of rendering the pilot's airplane control adequate to meet the control requirements from engine full on to engine off. It should be noted here that the tail cannot be operated very quickly, especially in the case of a wheel control. That is why, if possible, a lever should be provided, apart from its other advantage of registering the position of the tail plane to the pilot.

Slipstream acting on a tail set at a negative angle will render the airplane more tail heavy engine on than engine off. According to the design of the airplane this feature is in evidence to a greater or less degree. Pilots naturally like an airplane which has a small difference of trim engine on and off. In some airplanes the range of movement of the tail plane is not sufficient to provide adequately for this difference of trim, and elevator control which should be available for emergencies, has to be used up in trimming the airplane in what ought to be its normal range of flying speeds. The greatest fault of the modern airplane is its inadequacy of control at low speeds, and if it is out of trim as well, the fault is accentuated.

With stable airplanes it is possible to ascertain immediately, whether the tail plane has sufficient range for flying requirements, as the airplane with elevators free will take up definite stable trimming speeds, if they exist, with unstable airplanes, or airplanes only stable at low speeds, the problem is more complicated, and it is necessary to measure the forces on the control stick. For instance, if a pilot flies an airplane without any knowledge of its stability, he may find that it is nose heavy with full engine at 80 m.p.h. If it were a stable airplane, it would be certainly as nose heavy, if not more so, at 60 m.p.h.; however, if unstable, it might quite well have a neutral trimming speed at 60 m.p.h. (no force on the control stick) and be actually tail heavy at 50 m.p.h.

In most single-engined airplanes, the position of the axis of thrust unless the airplane be designed for some special purpose, does not affect the pilot nearly so seriously as the effect of the slipstream. Its actual effect cannot be dissociated from that of the slipstream as it occurs simultaneously, but the axis of thrust is not usually at a great distance from the center of gravity of the airplane. It should be noted that its effect may add to or subtract from that of the slipstream. Although not strictly relevant to engine control, the effect of the opening or closing of radiator shutters, especially with underslung radiators, has a marked influence on the longitudinal trim.

The engine torque is in general a small effect. It was noticeable on the D.H.2 when the engine was switched on and off, and on other small span airplanes. If the engine is opened gradually the torque is difficult to detect, but with an engine like a Monosoupape Gnome, which is switched off and on without throttling, the effect on a small span airplane is at once apparent.

As far as I know the gyroscopic effect of a large rotary engine, with one or two exceptions, only arises now-a-days with single-engined airplanes, and so consideration of it hardly assists a comparison with multi-engined airplanes. However, on a single-engined airplane this effect is felt in almost every natural maneuver that a pilot can carry out.

As the engine power is varied, its relations to the airplane control, as in (a), (b), (c) and (d) have been discussed as separate factors in a complex effect, such as the slipstream on the fin, or the position of the axis of thrust in its relation to the longitudinal control. But these in flight are so closely interrelated, at least to the feel of the pilot, that it may be well to consider the whole in relation to practical flying.

It might first be mentioned that the pilot may be flying along steadily and using his controls to overcome unsymmetrical forces due to, say, slip-stream. The slipstream may disappear due to engine failure, and cause the unsymmetrical forces to disappear also. Because for the moment the pilot has become accustomed to them, the effect is just as upsetting as if the airplane were subject initially to symmetrical forces, and unsymmetrical ones were suddenly introduced. Any sudden change of trim may necessitate the use of the airplane controls to maintain rectilinear flight, and the ease of doing this depends on whether the pilot is near to the margin of his control or not.

If the pilot is running up his engine on the ground, and proposes to do so without the tail being held down, he naturally opens the throttle gradually and pulls up his elevators to their maximum. The propeller, due to the position of its thrust axis, is trying to pull him on to his nose and he has to rely on the slipstream to make his elevators effective. It may be that his wheels are far back in relation to the center of gravity and his elevators will not hold down the tail. If he opens the engine suddenly, he will certainly tip on to his nose.

Similarly in getting off, the engine power is being increased, and the pilot is adjusting his elevators as the airplane gathers speed and the slipstream varies over his tail. As he gets off he will probably have to counteract the turning tendency with his rudder, or he will swing badly. He may have a slightly over balanced rudder, in which case, at a very low speed, the rudder when acted upon by the slipstream may behave in a curious way, and cause him to swing from side to side.

Suppose when the airplane has risen to about fifty feet the engine fails; the absence of slipstream may accentuate any possible tail heaviness, and if the pilot is not quick with his elevators the airplane will automatically stall itself. Added to this, the pilot has been overcoming the turning tendency owing to the slipstream on the fin, with his rudder, and may not appreciate immediately that the turning tendency has vanished. Thus he will tend to swing in the reverse direction, the force now being applied by him. His attitude in flight will then be highly dangerous.

If an inexperienced pilot flies an airplane with a strong turning tendency and a large alteration in longitudinal trim engine on and off he may do something like this—he takes off with the tail wheel adjusted for climbing. He flies round, and before gliding in to land he winds the wheel full back. He throttles right down, glides in and finds that he is going to overshoot badly. He decides to open the throttle and go round again for another attempt. He forgets, or has not time to wind the tail wheel forward. He finds that the nose goes up very easily, in fact too easily, the airspeed drops and a violent turning tendency develops. Before long he invites complete loss of control.

Effect on Multi-Engined Airplanes

As was mentioned before, the following remarks will be mainly confined to airplanes with two axes of thrust parallel to the fuselage and approximately on the same level. Airplanes with three and four axes of thrust are just touched on.

The principles underlying the effects (a) and (b) mentioned are the same for all airplanes. The engine torque (c) does not have much effect, while the gyroscopic effect (d) is hardly relevant nowadays to multi-engined airplanes. Therefore only (a) and (b) will be elaborated.

The effect of the engines in large airplanes is considerably more important, as at present there is no device in common use to assist the pilot in overcoming the large forces which may arise.

(a) A modern twin-engined airplane may have a monoplane or a biplane tail, and from one to four rudders. These may be entirely out of, or parts of them may be in, either slipstream. On most modern airplanes the propellers revolve the same way, and so both slipstreams have the same sense of rotation. These apply unsymmetrical forces to the tail, which could be neutralized if the propellers revolved opposite ways. This was I believe done in the case of some early examples of the Handley Page 0/400. For economy the engines are now both made of the same hand. The effect of slipstream is similar to that on a single-engined airplane, only rather more complicated, and of course larger forces relative to the pilot's strength are introduced.

Suppose that a twin-engined airplane has two fins and rudders, and that each fin and rudder is to some extent affected by the slipstream of each engine respectively. If one engine fails and its slipstream disappears, one rudder and fin is at once reduced in effectiveness. Since the rudders are interconnected, the whole rudder control is reduced just when it is most wanted.

An experiment has been proposed in which the fins should be offset in such a way that, if one engine fails, the slipstream of the other acting on the offset fin should, to some extent, neutralize the turning tendency set up.

It is quite obvious that the turning tendency is most violent at low speeds, for example, when the airplane is climbing, or taking off the ground, and on most twin-engined airplanes it is not possible to fly straight on one engine until a certain airspeed has been attained. This airspeed is usually considerably above the normal climbing speed.

(b) In a multi-engined airplane, the effect of the slipstream is important enough, but what is more important still to the pilot is the position of the axes of thrust. If there are two they must at least be just over a propeller's diameter apart, and probably more if they are to be kept fairly low and the fuselage has to come between. It must be remembered that the airplane has to be controlled getting off the ground, and the lower the axes of thrust, the less liable is the airplane to tip on its nose before it has gathered sufficient speed for the elevators to be effective.

Apart from this, the fact of having these two axes of thrust disposed as they are introduces unsymmetrical forces of the most violent description, if one engine fails. The violence in various airplanes varies due to engine power relative to size of the airplane, distance of engines apart, and the characteristics of the tail. In any case, momentarily, it is a troublesome thing for the pilot to have one engine fail when near the ground. Naturally in any good design it is essential to keep the axes of thrust as close as possible to reduce the pilot's difficulty.

It will be on the rudders that the pilot will rely to help him if one engine fails. If, added to this, he has one or two more axes of thrust disposed above the others, fresh complications arise, and render the problem of control still more complex. His elevators will now be involved, and besides the presence or absence of slipstream on the tail, the position of the top axes may introduce large forces. I do not think that unless a really reliable power plant can be designed it is fair to ask a pilot to cope with such a complexity of control, especially as it occurs on airplanes the size of which bring him, by reason of his lack of strength, toward the margin of his controlling powers. In a large airplane, control surfaces, though efficient, if too large for the pilot to operate successfully are bad enough; control surfaces, small enough for the pilot to use, but too small for the control requirements of the airplane, are useless.

Three thrust axes parallel and in a horizontal plane have been used with greater success, as the pilot should not find it so hard, owing to the increased size of the airplane in proportion to the power of each engine, to use his starboard and center power unit or his port and center unit, or both outside units, thus always being able to fly without one unit.

Thrust axes disposed in a vertical plane are not only difficult in the air, but much more so on the ground, where the pilot has to manage a structure which must run along the ground on its wheels to gather speed, and has to use his engine power to gain speed while his controls are ineffective owing to the lack of it.

In getting to know an airplane with variously disposed thrust axes, the pilot should thoroughly familiarize himself with the various effects of the engines on the airplane and his power of controlling it under all circumstances, not wait for an engine to fail suddenly when he may be near to the margin of his control. Thus, when near to the ground, he will see to it that he keeps as well as he can within the margin of control which happens to be small in any direction, to allow the maximum to meet an emergency. On the other hand, he will probably find that a judicious use of the engines may be made to assist his control, as in removing drift when landing and in other ways.

Details of Engine Controls on Multi-Engined Airplanes

A consideration of the effect of the engines on the airplane naturally leads up to a discussion of how the pilot controls the engines, and what means he has of knowing how his engines are behaving apart from the feel of the airplane and the sound of the engines. What he is immediately concerned with are his throttles, his revolution indicators and the control of his petrol system.

In a twin-engined airplane the pilot has much to occupy his attention. One of his hands is occupied with the wheel or control stick in conjunction with his feet on the rudder bar. He must use his throttles at a moment's notice, so that they must be very accessible and easy to operate. There are two kinds in common use, one consisting of two simple levers side by side, the other of one lever which opens both engines at once, or can be rotated to open one and close the other. There is a difference of opinion among pilots as to which of these is preferable. The first kind has the advantage of showing approximately how much open is each throttle, the second of allowing the engine to be varied with greater ease. However, in the latter case the pilot cannot tell with great precision what is happening to either engine except by the feel of the airplane or by looking at his revolution indicators. To those who have not flown an airplane with two engines running at once, it perhaps may not be immediately apparent that the pilot has lost his chief means of detecting quickly any ill behavior of an engine. In flying a single-engined airplane he constantly listens to the engine, which should afford him at least some warning if it is going to fail. When both engines are running at once it is quite difficult to tell if one engine is not running as it should do, and the pilot is compelled to look at the revolution indicator, or judge if the engine is missing slightly from smoke from the exhaust.

It is surprising how well a pilot can learn to manage the twin-lever type of throttle, if the levers are the right distance apart, neither too close nor too far, but just so that he can with a rotary movement of the palm of his hand push one lever back and the other forward. Even on German airplanes, where the throttles were provided with ratchets, this was to some extent possible.

Where there are four engines to look after, the differential type of throttle lever is almost imperative and the engines have to be run in pairs as on the Handley Page V/1500. The essential thing to guard against is too much rotation of the lever to open one engine and close the other completely. This should in no case exceed 90 deg. If it actually exceeds 180 deg. as was the case on an early Vimy, the pilot may have one engine full open and the other closed, and actually try to turn the lever the wrong way to equalize the engines, and simply jam the throttle. If this occurs when he must act quickly he is in a difficult position.

The system of wires and rods and the brackets which support them should be designed with the minimum of whip so that the pilot knows exactly what he is doing when he moves the throttle lever. In complicated systems such as are bound to arise on twin-engined airplanes, whip is liable to occur unless the system is well designed and fitted. If the pilot has throttled down and is landing and the airspeed is very low, one engine opening slightly on its own owing to whip in the throttle control will cause him to swing violently.

Hitherto the revolution indicators, owing presumably to the unreliability of long flexible drives, have been in nearly all cases fitted into the side of the engine unit. The pilot cannot see them both at the same time, and has to look round first to one side and then to the other in order to do so. When taking off this is extremely awkward, and until a satisfactory transmission is obtained by which they can easily be fitted on to the dashboard, this serious difficulty will remain. For the pilot's convenience on a twin-engined airplane a single dial with two needles superposed, but revolving in opposite directions, would be the neatest arrangement. He would be able to synchronize his engines with great precision and ease. In a four-engined airplane two dials with two superposed needles each could be employed.

When flying a multi-engined airplane, probably the ideal way would be to open all the engines out slowly and together. In practice, say with even four engines, pilots cannot do this, but always prefer to open one pair first, and then the other pair. This works quite well if none of the thrust axes are high off the ground; if they are, the awkwardness of opening the engines with low thrust axes and those with high thrust axes simultaneously will add to the natural difficulty of axes in such positions.

A frequent cause of engine failure on multi-engined airplanes has been failure of the petrol system. If the petrol system is complicated, as is often the case, no pilot should take the airplane into the air without spending sufficient time

on the ground to familiarize himself with its operation in every detail. In some cases the petrol system has failed owing to a mechanical defect. In some cases the petrol system has failed owing to incorrect handling by the pilot. Even if the pilot has spent some time in studying it, there may be extenuating circumstances attending a failure to handle it correctly in the air, owing to the pilot's mind being so occupied.

In very large airplanes the petrol system is usually handled by a mechanic, who is supposed to anticipate the pilot's requirements, so that whatever the pilot chooses to do with the engines, he may have an adequate supply of petrol. In this case the pilot is left considerably freer to look after the airplane, but owing to the increased size and number of engines, he has still a great deal to do, excluding the drain on his physical energy owing to the weight on the controls.

It was largely owing to war requirements, that is of rendering the petrol system still workable when parts of it might be out of action due to gunfire, that petrol systems became complicated. Peace requirements demand a return to the simplest kind of system, and one that imposes the least possible strain on the pilot. Unfortunately, the most likely time for the petrol system to give trouble on an untested airplane was when it was taking off the ground at a low speed, as the trouble which could not be detected or located when running upon the ground arose as soon as the airplane commenced to fly.

Practical Flying Notes on Twin-Engined Airplanes

These notes are based on flying experience with the Handley Page 0/400 fitted with twin Rolls Eagle VIII engines, an experimental one fitted with four 200 hp Hispano engines mounted in tandem pairs, the Vickers Vimy with twin Fiat and twin Rolls engines, the German A.E.G. Bomber, and the D.H.10 with twin Liberty engines.

The Handley Page 0/400 was introduced and flown for a considerable time on service without any serious troubles being reported due to turning tendency caused by engine failure on twins. This was mainly due to the fact that relative to the power of its engines the airplane was of large dimensions. If one engine dropped revolutions the turning tendency was not violent, the whole airplane being comparatively sluggish due to its large moment of inertia. Curiously enough, the fact that it had overbalanced rudders, though sometimes commented on, was not seriously complained of. These rudders undoubtedly did cause the airplane to swing from side to side when taking off the ground, and if they were abandoned in the air, they immediately took charge and set up a violent swing. There was, however, little force required to prevent them doing this.

Nowadays Handley Page airplanes have the propellers both of the same hand; some earlier examples had propellers of opposite hand, and the difference between the two arrangements was felt by pilots. There is a turning tendency due to slipstream, which, though not very marked, can be detected when both propellers revolve the same way. Where the propellers revolved opposite ways the turning tendency entirely disappeared.

It was when airplanes of smaller dimensions for the same power were flown that the first serious trouble arose due to the failure of one engine. The Vickers Vimy and the D.H.10 both swung violently round if one engine failed, the latter more quickly than the former owing to its small size. If the pilot is taking off the ground and has not had time to gain sufficient airspeed to fly straight on one engine, the obvious thing to do if one engine fails is to throttle the other right down, and if he cannot, by putting the nose down, attain this speed before being compelled to land, he must land wherever he is. There is no other alternative. Not only is this the case, but he must be very alert in throttling down the engine that is still running, or otherwise he will find that the airplane is swinging round flat, and thus his longitudinal control has lost much of its power; in fact, on an airplane like a D.H.10 the safest thing is undoubtedly to switch the engine off. This course immediately deprives the pilot of the assistance of any engine power, and if he can afford to control the airplane with the engines throttled down and not switched off, his glide is flattened and he has more chance of landing on a good piece of ground.

If there is any whip in the throttle control the pilot will find it difficult to open the engines out evenly, either with the twin-lever type or the differential type of throttle. Whip in the throttle control of a single-engined airplane is annoying but not a serious difficulty to the pilot as in a twin.

Before attempting to taxi out on a twin that has not been tested the pilot should take all preparatory measures that are possible on the ground to ensure that his petrol system will be satisfactory in the air. If the petrol is pumped up to a gravity tank which feeds the engines, he should make sure that the delivery from the gravity tank is considerably in excess of the amount required by both engines by taking the petrol flow at both carburetors simultaneously, both with the tail skid on the ground and the airplane in flying position. If he is sure of an adequate flow from his gravity tank, then he is sure of enough petrol to tide him over the first few hundred feet of his climb, which is the difficult period from the airplane point of view. He should run up each engine separately so that he may listen to it without being confused by the noise of both running at once. He should make sure that his throttles work easily and do not slip backward or forward when the hand is removed from them.

It is always wise to taxi for a certain distance before taking off (even though it is possible to take off from the position of running up) so as to give the petrol pumps (if the petrol system includes them) a chance to work a little. It is then possible while taxying to give one or two bursts with each engine to see how it opens out, allowing the airplane to swing round either way.

Unless the pilot is not only accustomed to the type, but is also familiar with the particular airplane, it is unwise to attempt a fancy take-off, such as across wind with one wing down, or by opening the throttles violently and pulling the airplane off the ground at low airspeed. This may be done on a single-engined airplane without involving much risk if the engine fails. The pilot should open the throttles gently and take a good run over the ground if it is smooth enough to permit of this, and even when he has left the ground should hold the nose down near the ground until he has attained an airspeed of 60 m.p.h. If one engine fails and he is 15 feet off the ground doing 45 to 50 m.p.h., he has no chance whatsoever of controlling the swing of the airplane. He has only to try this at a safe height by switching off one engine at various airspeeds from 50 m.p.h. upward and he will soon find out his power of controlling a swing. A D.H.10 will swing through 90 deg. in about 3 sec. if one engine is switched off at 50 m.p.h. The safest way to take off is with one hand on the throttles so that if one engine fails the throttles may both be pulled back. If the pilot puts the nose of the airplane down it will then commence to glide, and if he has sufficient height to attain the airspeed at which he can fly reasonably straight on one engine, assisted by a judicious use of rudder, he can then again open out his sound engine and use it to carry him on and effect a landing on good ground. If he is very near the ground and an engine fails, even before he can throttle down the other engine the airplane will have swung through a certain angle and thereby considerable drift will have been set up, which if there be no room to sideslip, it will be impossible to eliminate before touching the ground. Thus he is almost certain to damage his undercarriage, though probably nothing of a more serious nature will occur.

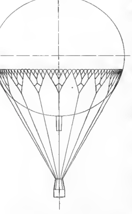
When taking off in bumpy weather the airplane is slewed about in the bumps, and the sound of the engines is always less regular than in calm weather. This adds to the pilot's difficulties in detecting a faulty engine as he can only tell it by the feel of the airplane, the sound of the engines or by the revolution indicators. His first method of knowing is impaired by the bumps, as a bad bump sometimes feels similar to a swing under the influence of engine, his second method by the irregularity of the sound of the engines in gusty weather and by the fact that both engines are running together and the sound of the good one obscures the sound of the bad one, and his third method by the fact that it is very awkward to look round at the revolution indicators, especially when he cannot tell by other means which is the defective engine. As laid out in detail, these difficulties appear of the gravest nature. In practice an intelligent pilot has always his flying instinct to help him, which is a very difficult thing to define, but it is clear that the greatest caution should be exercised due to the special characteristics of this type of airplane.

The Italian Balloons of the G. B. Race

The Italian free balloons Andens and Trionfale which participated in the ninth Gordon Bennett race, last summer marked an interesting departure in balloon design from standard practice. Owing to the courtesy of Lieut. Col. A. Guidoni, Italian air attache in Washington, D. C., we are enabled to give the following particulars regarding these craft.

They are of spherical form, with a maximum diameter of 52 ft. 6 in. and capacity 77,500 cu. ft. The gross lift is about 3,580 lb. The valve has a diameter of 2 ft. 4 in.; the upper panel has a length of 28 ft.

The most peculiar characteristic of these balloons is their light weight, which is due to the absence of a suspension net, the basket being rigged to a steel cable fitted around the envelope 8 ft. below the equator. This cable forms 96 small



OUTLINE DRAWING OF THE ITALIAN BALLOONS OF THE G B RACE

parabola whose vertices support the cotton wires that run to the suspension circle and then to the nacelle. This system of suspension has the further advantage that if the envelope is ripped the lower part of the same acts as a parachute and thus slows down the descent.

The fabric of the upper hemisphere is double and that of the lower hemisphere is single. The basket is 3 ft. 4 in. high and wide and 4 ft. 4 in. long.

The weight items are as follows:

Envelope	614 lb
Basket	106 lb.
Equipment	300 lb
Crew (2)	360 lb
Ballast	2,200 lb
Gross lift	3,580 lb

As the efficiency of a free balloon is measured by the ratio of ballast to total weight, the Italian balloons appear very remarkable indeed, for their efficiency ratio is *0.61*. This is, we believe, the highest ever reached.

England to Subsidize Air Transport

Reports coming to the United States indicate that the British Government at last has followed the policy of the French and German Governments and has taken a step toward the development of civil aviation. This is indicated by an announcement from the Air Ministry of a grant of $300,000 a year for direct assistance to companies engaging in air traffic. The Advisory Committee suggested twice that amount, but while the grant is small it is looked upon as a step in the right direction and one which will serve as an inspiration for progress.

The money is available for companies operating over approved air routes on a basis of 25 per cent of the total revenue earned by carrying passengers, mail and freight. The grant becomes effective the first of next year. A company in order to obtain the benefit of the grant must show that it has developed business and flying time equal to a certain minimum which will be stipulated under the rules of the grant, and it must use aircraft of British manufacture fitted with British made engines.

The routes thus far approved are all trans-channel flights to Paris, Brussels and Amsterdam, but extensions and additional routes are planned, and will be announced before the grant becomes effective.

The grant comes just in time to prevent a big decline in British aviation development. Recently two companies suspended business and aviation in England generally was in a bad way. It is now hoped that the two discouraged companies will try again and others will enter the field.

The delay before the money becomes available is considered a serious handicap, however, as last year France alone spent twice that much in developing French civil aviation, and therefore advanced considerably, while Britain dropped back. Germany also has made much headway, but both these countries have the advantage of inland routes. This has resulted in a growing demand for the development of inter-island routes.

It is urged that the grant should stimulate the use of real commercial aircraft designed for that purpose and carrying big loads with a minimum of power used. War time machines have been the greatest drawback to the development of commercial flying since these craft are not a suitable type to make such a business profitable.

F. Handley Page has expressed himself as pleased with the Air Ministry's announcement, and said that although the grant was small it was a recognition by the Government of the value of civil aviation. He said that his company would now be able to stand on the same ground with foreign companies. "Previously in dealing with any country which had services subsidized by the Government," Mr. Page said, "there was no guarantee on our side that our service would have the support of our Government in any way. Now we have a definite starting point and a definite guarantee if a certain amount of freight is forthcoming."

Mr. Handley Page said that one of the most important points was that if it is possible now to make a profit at the present scale of charges without carrying full loads, the subsidy by making up the difference would permit a reduction in charges and thus in turn would increase the volume of traffic to such an extent that the business could be launched on a proper paying basis.

Brief History of Launching Catapults

Catapults were used for throwing heavy missiles in the time of Xerxes and his son, Alexander the Great, and probably before that

The first attempt to use a catapult for launching an airplane was made by Prof Samuel P Langley in 1896, when he launched model airplanes successfully from a catapult. A few years later he attempted to launch a man-carrying airplane from a catapult in Chesapeake Bay, but this attempt was not successful

The first successful flight of an airplane made from what might be termed a catapult was made by Orville Wright, Kitty Hawk, Dec. 17, 1903 This device was an inclined monorail with two rails outboard which assisted in balancing the plane laterallly The plane was released by a trigger and accelerated by the use of gravity, which assisted the plane along the monorail.

The idea of applying the catapult for use in the Navy was first suggested in 1911 by Capt. Washington I Chambers, who was at that time in charge of the development of Naval Aviation. Assisted by Lieut. T G Ellyson, U S. N., the first Naval Aviator, Naval Constructor H C Richardson, U S N., and Admiral N C Twining, U S N of the Bureau of Ordnance, a catapult was developed under the supervision and direction of Captain Chambers at the Washington Navy Yard. The first attempt to launch a plane was made at Annapolis and was a failure. As a result of this test, however, certain defects were discovered and corrected in a second catapult which was built at the Washington Navy Yard out of scrap material, and two successful flights were made from this catapult by Lieutenant Ellyson. The first flight was made on Nov 12, 1912, in a Curtiss hydro-airplane, and the second in a Curtiss flying boat.

A means of flying from an inclined single steel wire, with two lighter steel wires supporting the plane laterally, was successfully demonstrated by Lieutenant Ellyson at Hammondsport, but this was not further developed because it was not considered practicable for use from a ship, particularly if the ship was rolling

Due to the lack of funds and lack of interest in aviation on the part of the Navy Department, as well as to the beginning of the World War, no further actual experiments were carried out until 1915, when a new and larger catapult designed by Naval Constructor Richardson of the Bureau of Construction and Repair, and which further eliminated some of the faults of the first catapult, was installed on a barge at Pensacola. From this seven or eight successful launchings were made, Lieut. P N L. Bellinger being the first officer to fly from this catapult.

As a result of these successful tests, authority was obtained by Capt H C. Mustin to install this catapult on the North Carolina, an armored cruiser. This was done hurriedly under his direction and several successful launchings were made from the catapult on that ship, Captain Mustin being the officer to make the first flight. Authority was then obtained by Captain Mustin to design and install an improved type of catapult on the North Carolina. This work was completed in 1916, and many successful launchings were made from this catapult, Lieut Comdr. G. deC. Chevalier being the first officer to fly from this catapult.

The Navy Department then installed catapults on the armored cruisers Seattle, Huntington and North Carolina. During the early winter of 1916, successful flights were made from these cruisers. At the time the United States entered the war, guns were thought to be of far more importance to the armored cruisers than the catapults and aircraft with which they were then equipped, and as these catapults and aircraft interfered slightly with the gunfire of the ship, orders were given to remove the catapults from the cruisers and this was done.

In order that the aviators might receive training in being launched from a catapult, one of these was installed on a barge at Pensacola, which was the aviation school, and was used extensively in training aviators to fly from catapults. This is shown in the accompanying illustration.

AIRCRAFT LAUNCHING CATAPULT INSTALLED ON A BARGE AT PENSACOLA, FLA
(Official Photograph, U S Navy)

In the first Navy catapult, the car upon which the plane rested was permitted to leave the track and fall into the water at the end of its run. In the later design of catapult, attempts were made to stop the car after its run by means of brakes and buffers, in order that it might be used again This was not at first successful, and in the catapults installed upon the Seattle, Huntington and North Carolina, the cars were again permitted to leave the track and fall into the water In order that they might not be lost, means were provided whereby the car automatically picked up a rope at the end of the run, which permitted its being hauled aboard after it fell in the water Naval Constructor Richardson, who assisted in the design of all catapults for the Navy, continued to search for a practical means of stopping the car at the end of its run, and it may be stated that he has perfected a means of doing this.

Training Course at A. S. Mechanics' School

What is believed will mean a material gain in the efficiency of the Air Service Mechanics' School at Kelly Field is the addition of a course of mathematical instruction to every course taught in this school The course includes elementary mathematics up to and including the principles of algebra and geometry. Every student entering this school for a course must first complete this elementary work before he can specialize on any branch of aviation.